Newton's Laws of Motion

Presented by: -

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Contents of the Presentation

- Newton's First law of Motion
  - Balance and Unbalanced Force
- Newton's Second law of Motion
  - Free – Falling Motion
  - Motion with Air Resistance
- Newton's Third law of Motion

Objective of the Presentation

The presentation would help the learner to: -

- State Newton's laws of motion
- Apply Newton's laws of motion in practical life
- Solve problems relating to Newton's laws of motion

Newton's First Law of Motion

An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force. This tendency to resist changes in their state of motion is described as inertia.

2 Kinds of States

Forces are Balanced

Objects at Rest
$(v = 0\ m/s)$

$a = 0\ m/s^2$

Stay at Rest

Objects in Motion
$(v \neq 0\ m/s)$

$a = 0\ m/s^2$

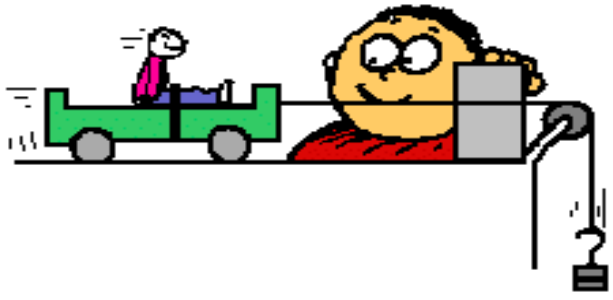
Stay in Motion
(same speed and dir'n)

Emergency Brakes

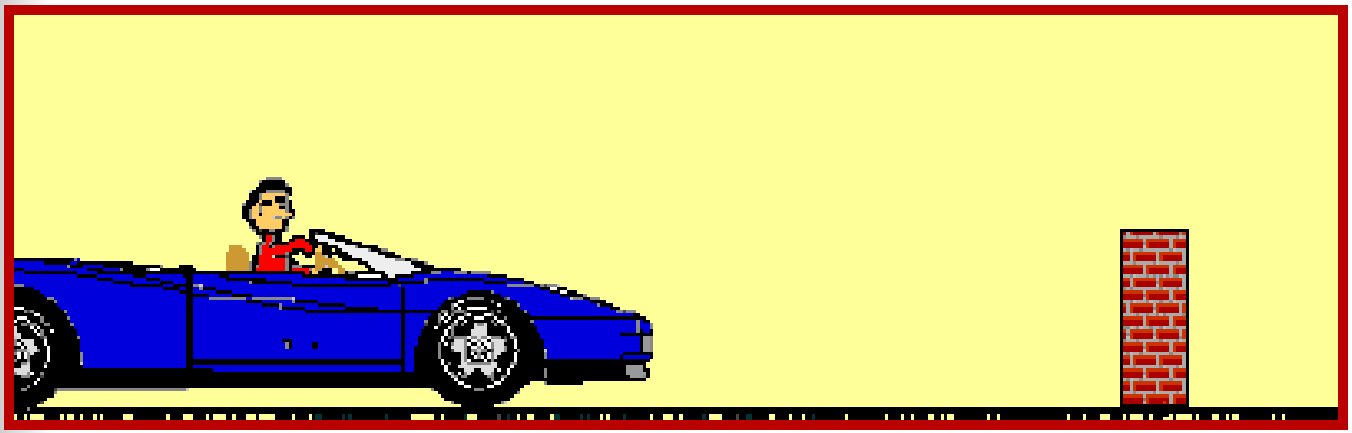
In an automobile while it is braking to a stop you can experience inertia

The force of the road on the locked wheels provides the unbalanced force to change the car's state of motion, yet there is no unbalanced force to change your own state of motion. Thus, you continue in motion, sliding forward along the seat. A person in motion tends to stay in motion with the same speed and in the same direction ... unless acted upon by the unbalanced force of a seat belt.

Seat belts are used to provide safety for passengers whose motion is governed by Newton's laws. The seat belt provides the unbalanced force which brings you from a state of motion to a state of rest. Perhaps you could speculate what would occur when no seat belt is used.



Example 1



If the car were to abruptly stop and the seat belts were not being worn, then the passengers in motion would continue in motion. Assuming a negligible amount of friction between the passengers and the seats, the passengers would likely be propelled from the car and be hurled into the air. Once they leave the car, the passengers becomes projectiles and continue in projectile-like motion.

Now perhaps you will be convinced of the need to wear your seat belt. Remember it's the law - the law of inertia.

Example 2

If the truck were to abruptly stop and the straps were no longer functioning, then the ladder in motion would continue in motion. Assuming a negligible amount of friction between the truck and the ladder, the ladder would slide off the top of the truck and be hurled into the air. Once it leaves the roof of the truck, it becomes a projectile and continues in projectile-like motion

Pass the Water Exercise

There is a Pass the Water exercise that demonstrates this principle. If students participate in a relay race carrying a plastic container of water around a race track, the water will have a tendency to spill from the container at specific locations on the track. In general the water will spill when:

the container is at rest and you attempt to move it

the container is moving in one direction and you attempt to change its direction.

the container is in motion and you attempt to stop it

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Newton's Second Law of Motion

The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object

The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object

Newton's Second Law of Motion – cont'd

Newton's second law of motion can be formally stated as follows:

The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

In terms of an equation, the net force is equal to the product of the object's mass and its acceleration.

$$F_{net} = m * a$$

Determinants of second law

Forces are Unbalanced

↓

There is an acceleration

↙ ↘

The acceleration depends directly upon the "net force"

The acceleration depends inversely upon the object's mass.

Practice problem

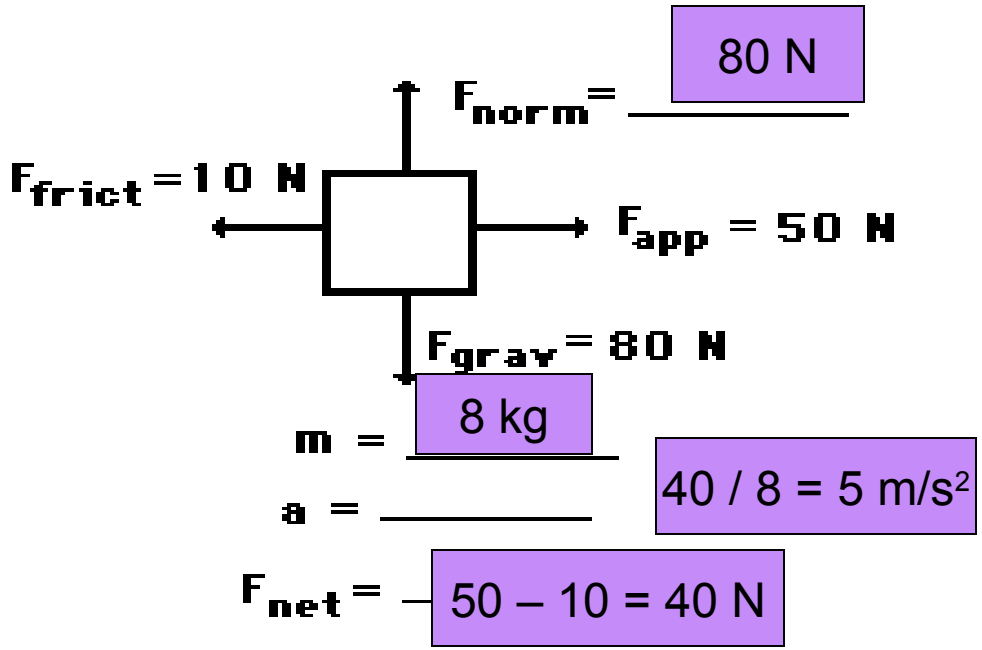
The process of determining the acceleration of an object demands that the mass and the net force are known. If mass (m) and net force (Fnet) are known, then the acceleration is determined by the equation:

$$a = \frac{F_{net}}{m}$$

Thus, the task involves using the above equations, the given information, and your understanding of Newton's laws to determine the acceleration.

Practice Problem – cont'd

- An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. The mass of the object is 8 kg. Use the diagram to determine the normal force, the net force and the acceleration of the object. (Neglect air resistance.)

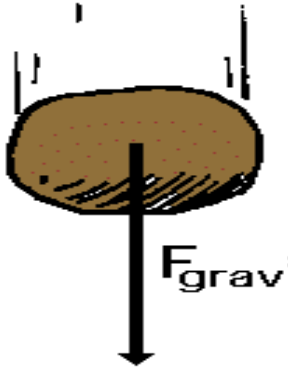


Application – Free Fall

- Free-fall is a special type of motion in which the only force acting upon an object is gravity. Objects, which are said to be undergoing *free-fall*, do not encounter a significant force of air resistance; they are falling under the sole influence of gravity. Under such conditions, all objects will fall with the same rate of acceleration, regardless of their mass.

Application – Free Fall

m = 10 kg



$F_{grav} = 100\ N$

$$a = \frac{F}{m}$$

$$a = \frac{100\ N}{10\ kg}$$

$$a = 10\ m/s^2$$

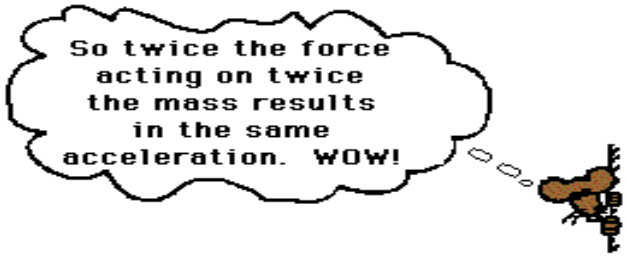
m = 1 kg

$F_{grav} = 10N$

$$a = \frac{F}{m}$$

$$a = \frac{10\ N}{1\ kg}$$

$$a = 10\ m/s^2$$



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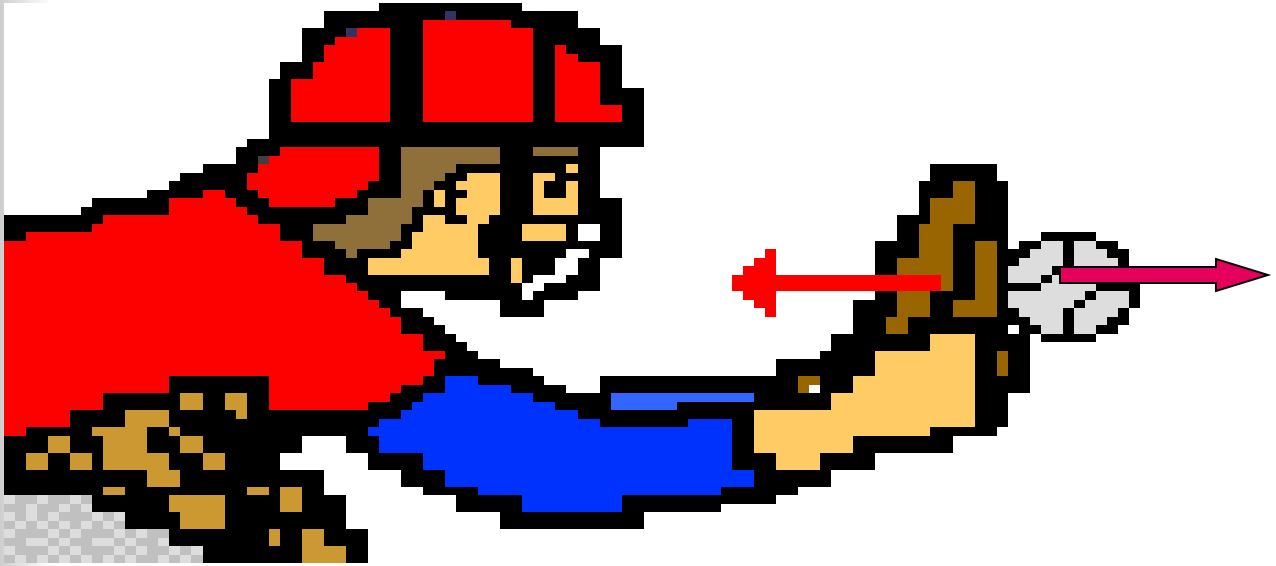
Newton’s Third Law of Motion

- According to Newton's third law, for every action force there is an equal (in size) and opposite (in direction) reaction force. Forces always come in pairs - known as "action-reaction force pairs”

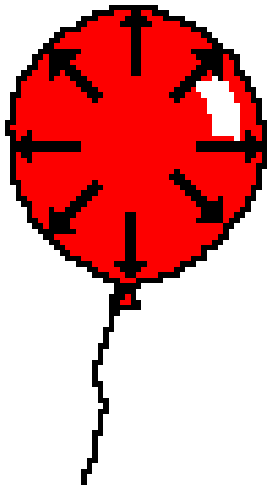
Examples



When the fielder catches the ball, he exerts a force, directed towards right and the ball exerts an equal force directed towards left

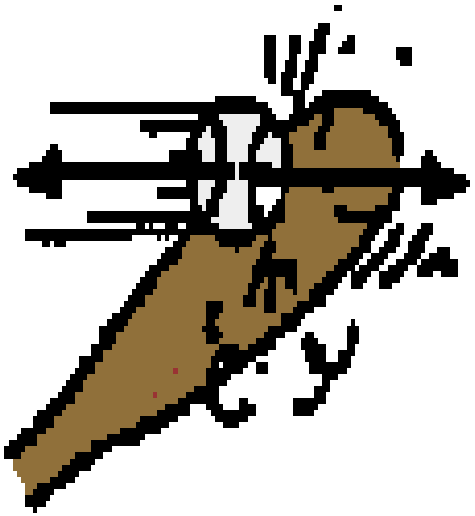
Examples Contd

A gun recoils when it is fired. The recoil is the result of action-reaction force pairs. As the gases from the gunpowder explosion expand, the gun pushes the bullet forwards and the bullet pushes the gun backwards.



Examples Contd

the bat forces the ball (the reaction)



The baseball forces the bat (an action)

Recapitulation

- 1st Law of Motion

  An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

- 2nd Law of Motion

  The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object

  $$F_{net} = m * a$$

- 3rd Law of Motion

  For every action force there is an equal (in size) and opposite (in direction) reaction force.

Thank You